



METHANE GUIDING PRINCIPLES

REDUCING METHANE EMISSIONS



Best Practice Guide: Energy Use



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Disclaimer

This document has been developed by the Methane Guiding Principles partnership. The Guide provides a summary of current known mitigations, costs, and available technologies as at the date of publication, but these may change or improve over time. The information included is accurate to the best of the authors' knowledge, but does not necessarily reflect the views or positions of all Signatories to or Supporting Organisations of the Methane Guiding Principles partnership, and readers will need to make their own evaluation of the information provided. No warranty is given to readers concerning the completeness or accuracy of the information included in this Guide by SLR International Corporation and its contractors, the Methane Guiding Principles partnership or its Signatories or Supporting Organisations.

This Guide describes actions that an organisation can take to help manage methane emissions. Any actions or recommendations are not mandatory; they are simply one effective way to help manage methane emissions. Other approaches might be as effective, or more effective in a particular situation. What readers choose to do will often depend on the circumstances, the specific risks under management and the applicable legal regime.

Summary



Natural gas, which consists mainly of methane, is used as a fuel throughout oil and gas operations, for compression, generating electricity, heating, dehydration and removing acid gas. Combustion engines which use natural gas as a fuel are generally designed to run with at least 98% combustion efficiency (that is, at least 98% of the gas will be burned), but some methane is released as a result of the natural gas that has not been burned. Emissions released in this way are known as 'methane slip'. Even though methane slip is generally a small percentage of the fuel used, in operations that use a significant amount of energy, methane slip can be a major source of emissions. Using natural gas as a fuel can also result in emissions associated with the engine burning the gas, such as emissions from cylinders or rod packing. Reducing the amount of natural gas used as fuel reduces methane emissions, and may cut energy costs.

Methane emissions from energy use in oil and gas operations can be reduced by doing the following.

- Using electricity or other types of power instead of natural gas
- Making processes more efficient, which reduces the amount of energy (in the form of natural gas) used
- When natural gas needs to be used as a fuel, improving the efficiency of the combustion engines

Reductions in fuel costs mean that the cost of some options is recovered in a few months to a year.

Best practice for reducing methane emissions from energy use in oil and gas operations:

Keep an accurate inventory of where natural gas is used as fuel

Use electricity or pneumatic power from compressed air or nitrogen

Improve the energy efficiency of operations and equipment

If natural gas needs to be used as a fuel, improve the efficiency of combustion engines

Track progress in reducing the use of natural gas as fuel

Introduction



Natural gas, which consists mainly of methane, is used throughout the oil and gas industry as fuel for combustion engines used for compression, generating electricity, heating, dehydration and removing acid gas. Combustion engines that use natural gas as a fuel are generally designed to have at least 98% combustion efficiency (meaning that at least 98% of the natural gas is burned), so some methane is released as a result of the natural gas that has not been burned. Emissions being released in this way are known as 'methane slip'. Methane slip is generally estimated, rather than measured, and estimates can vary depending on how the estimate is produced. For example, in the United States, methane slip estimates in the US Environmental Protection Agency's Compilation of Emission Factors (AP-42)¹ and their 'Inventory of US Greenhouse Gas Emissions and Sinks' (GHGI)² are comparable, but are much higher than the estimates in Subpart C of their US Greenhouse Gas Reporting Program³. Because of these differences in emission factors, all emission estimates should be viewed with caution.

Even though methane slip is generally a small percentage of the natural gas used as fuel, in the parts of the supply chain that use a significant amount of natural gas as fuel for compression, removing acid gas, dehydration or other uses, methane slip can be a major source of emissions. Using natural gas as a fuel also results in emissions associated with the engine burning the gas, including leaks from parts of combustion engines and pneumatic devices driven by natural gas.

This document gives guidance on best practice for reducing emissions directly associated with energy use in oil and gas operations. Other best-practice guidance is given in the guides for pneumatic devices, venting and equipment leaks. Overall, reducing energy use can lower methane emissions in several ways. However, there is the possibility that reducing the use of natural gas as fuel for one activity may increase emissions from other activities (for example, when electricity replaces a combustion engine and the electricity is generated using natural gas).

Reducing the amount of natural gas used for fuel may also lower energy costs.

Mitigation strategies



- Methane emissions can be prevented by replacing natural gas as a fuel with electrical power or pneumatic power using compressed air or nitrogen.
- Energy-efficiency measures reduce energy use and methane emissions. Energy use can be reduced by improving operations using gathering lines.
- Methane emissions can be reduced by improving the efficiency of fuel combustion.
- Because mitigation strategies prevent or reduce the use of natural gas, some can pay for themselves in less than a year.

Methane emissions from energy use (natural gas being used as fuel) in oil and gas operations can be reduced by:

- using electrical power or pneumatic power using compressed gas or nitrogen;
- reducing fuel use by improving the efficiency of the process the energy is used for; and
- when natural gas needs to be used, making combustion more efficient.

The mitigation strategies are summarized in the table below, and more detailed descriptions are given in the following pages. Some strategies designed to improve energy efficiency through the design of systems are described in the best-practice guide on engineering design practices. Guides on pneumatic devices, venting and leaks also set out mitigation strategies that have ties to energy use. Links to more information are provided in appendix 1.

Mitigation strategy	Description
1. Use electricity or other types of power rather than natural gas	1a Install electrical compressors
	1b Replace natural gas used in compressor starter motors with electrical starters or pneumatic starters using air or nitrogen
2. Reduce fuel use by improving energy efficiency	Make more efficient use of energy in gathering lines
3. Improve the efficiency of fuel combustion	3a Replace cylinder unloaders
	3b Install automated air-to-fuel ratio controls

Because mitigation strategies prevent or reduce the use of natural gas, some can pay for themselves in less than a year, depending on energy prices.

Mitigation strategy 1a: Install electrical compressors⁶

Compressors powered by natural gas, which are used in gas gathering and transmission, can be replaced with electrically driven compressors (if an electricity supply is available). If electrical power is not available on the site, a generator can be installed, to power compressors as well as other equipment (see the best-practice guide on pneumatic devices). Electrification eliminates the emission of gas that has not been burned (methane slip). Although electrification can reduce methane slip from compressors, it may not reduce the total methane slip, if the electrical power is generated using natural gas as a fuel. However, even if natural gas is used to generate the electricity used in the electrification of compressors, total emissions may still be reduced as electrification also eliminates emissions from engine components.

US EPA Natural Gas Star partners⁴ have reported that electric compressors also have lower maintenance costs than gas-powered compressors, making this mitigation strategy particularly cost-effective for remote locations with electrical power and high maintenance costs.

Figure 1: Natural gas compressor



Source: BP

Reduction in emissions and recovering costs

A site that replaced natural-gas compressors with ratings totaling more than 15,000 horsepower with electric compressors reported an initial outlay of US\$6,000,000. The reduction in methane emissions can be quantified based on a methane-emission rate of 60 cubic meters per year per horsepower, and on this site were approximately 1 million cubic meters per year⁴. The time it would take to recover costs at this site ranges from approximately one year to more than five years, depending on gas prices, electricity prices and other factors.

Mitigation strategy 1b: Replace natural gas used in compressor starter motors with electrical starters or pneumatic starters using air or nitrogen^{7, 8}

In the natural-gas industry, combustion engines are often started using gas-expansion turbine motors. The starter motors use high-pressure natural gas, which is stored in a tank. To start the compressor, the gas is expanded through the starter turbine and then vented.

Each start-up uses approximately 1.4 cubic meters of gas for every 100 horsepower of motor size. The exact volume of gas needed depends on the design of the starter motor. The emissions also depend on the pressure the natural gas is stored at, which determines the energy released by the gas-expansion turbine. Methane emissions can be eliminated by using compressed air or nitrogen instead of natural gas. If electricity is available, the gas-expansion turbine motor can be replaced by an electrical motor. As for mitigation strategy 1a, this mitigation strategy eliminates methane emissions, but total emissions will depend on how the electricity or pneumatic power is generated.

Reduction in emissions and recovering costs

Natural Gas Star partners have reported reductions of 40,000 standard cubic meters per 3,000 horsepower compressor per year by replacing gas-turbine starters with pneumatic or electrical alternatives.^{5,6} This scenario involved 10 start-ups per year. Costs for electric starters depend on engine size, but are typically in the range of US\$1,000 to US\$10,000. Costs and emission reductions depend on the size of the compressor, the number of start-ups and whether the replacement is an electrical motor or a pneumatic one using compressed air or nitrogen. For pneumatic replacements, payback times of several months have been reported. For electrical motors, where the initial outlay can be higher, payback times can be up to several years.

Mitigation strategy 2:

Make more efficient use of energy in gathering lines⁹

Gathering systems deliver gas from networks of wells to processing plants. The volume of gas processed and the capacity of the network changes because of changes in production, liquid and hydrate building up in the gathering lines, changes in the composition of the gas and changes in atmospheric and weather conditions. Extra compression and energy use may be needed at times for the network to function and to prevent flaring of gas that could not otherwise be used by the network.

The capacity of a gathering system can be increased, and the amount of energy used decreased, through frequent clearing of lines (pigging), and minimizing the build-up of liquid and hydrate through line heating or chemical injection. This reduces the amount of energy used and may also prevent flaring of gas (see the best-practice guide on flaring). Overall, multiphase flow through gathering pipelines should be avoided where possible⁷. This can be done by separating gases and liquids at

wells sites (see the best-practice guides on venting and flaring). However, pigging, chemical injection, separating, and storing liquids can also lead to methane emissions, so total methane emissions in the supply chain should be examined carefully.

Reduction in emissions and recovering costs

Some strategies for reducing drops in pressure within gathering lines, and reducing energy use in moving gas through gathering lines, can both reduce emissions from energy use and lead to extra emissions. For example, frequent pigging will reduce energy use but can also lead to venting when the lines are pigged. Chemical injection, if done by pneumatic pumps powered with natural gas, can reduce hydrate formation, but can also lead to an increase in vented emissions. Mitigation strategies can reduce or eliminate these emissions (see the best practice guides on pneumatic devices and venting). The economic impact of reducing emissions will depend on the site.

Figures 2a and 2b: Pigging Operations



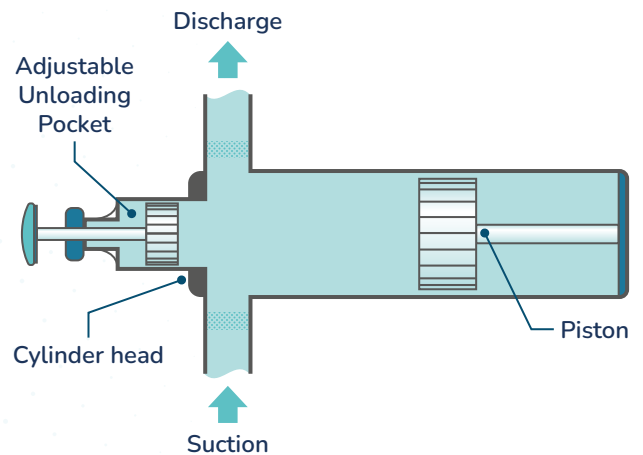
Source: BP



Mitigation strategy 3a: Replace cylinder unloaders⁴

A cylinder unloader is used to adjust the output of a reciprocating engine, by adjusting the volume of a cylinder. Cylinder unloaders can release methane through leaking o-rings, covers or pressure packing. These leaks can be detected using infrared cameras. Unloaders, which need frequent maintenance, can also lead to emissions and shutdowns of reciprocating compressors.

Figure 3: Cylinder Unloader



Reduction in emissions and recovering costs

Natural Gas Star partners⁸ have reported the cost of installing unloader replacements to be US\$40,000 to US\$50,000 per compressor, and payback periods are typically one year, depending on fuel prices. Other benefits may include reduced maintenance and fewer unscheduled shutdowns. Partners have reported average emission reductions of more than 100,000 standard cubic meters per year per compressor.

Mitigation strategy 3b: Install automated air-to-fuel ratio controls⁵

Engines in natural-gas supply chains are run under a variety of loads and air-to-fuel ratios. Low air-to-fuel mixtures (rich burn) are used when a greater horsepower is needed. High air-to-fuel mixtures (lean burn) are used when lower horsepower and greater fuel efficiency are the goals. Rich burn results in more emissions of unburned gas (mainly methane) and fewer emissions of nitrogen oxide (NO_x). Lean conditions cause lower methane emissions, but more NO_x emissions. Installing automated air-to-fuel ratio control systems allows the performance of an engine to be maximized. These systems might also allow captured hydrocarbon emissions to be used as fuel, delivered to the engine in the air intake. The control system adjusts the fuel intake to account for extra hydrocarbons in the air intake.

Automated air-to-fuel ratio controls benefit engines rated at over 1,000 horsepower. The greatest improvements are for rich-burn, high-speed, turbocharged engines ranging in size from 1,000 horsepower to 3,000 horsepower⁹.

Reduction in emissions and recovering costs

Reported average fuel savings associated with automated air-to-fuel ratio controls are in the order of 1 million standard cubic meters per year per engine⁹. If the average combustion efficiency in the engine is 98 to 99%, the reduction in methane emissions would be in the order of 10,000 to 20,000 standard cubic meters per engine per year. The initial outlay is typically US\$140,000 per engine, leading to typical payback periods of approximately one year⁹.

Checklist



The following checklist assesses progress in reducing emissions from energy use.

Activity	Completed	Percentage of equipment or sites involved
✓ Keep an accurate inventory of where natural gas is used as fuel		
✓ Use electrical compressors		
✓ Replace natural-gas pneumatic starters with electrical starters or pneumatic starters driven by compressed air or nitrogen		
✓ Reduce energy use in gathering operations by frequent clearing of lines (pigging) and minimizing the build-up of liquid and hydrate through line heating or chemical injection		
✓ Replace cylinder unloaders		
✓ Install automated air-to-fuel ratio controls		

Appendix 1



Links to more information about mitigation strategies

Mitigation strategy	Description	Link to more information
1. Use electricity or other types of power rather than natural gas	Install electrical compressors	(4)
	Replace natural gas used in compressor starter motors with air or nitrogen	(5)
	Install electric starter motors	(6)
2. Reduce fuel use by improving energy efficiency	Make more efficient use of energy in gathering lines	(7)
3. Improve the efficiency of fuel combustion	Replace cylinder unloaders	(8)
	Install automated air-to-fuel ratio controls	(9)

References



- 1 US EPA, AP 42 Section 3.2 Natural Gas-Fired Reciprocating Engines. <http://www.epa.gov/ttn/chief/ap42/ch03/related/c03s02.html>
- 2 United States Environmental Protection Agency (US EPA) 2019 'Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2017' (April 2019)
- 3 40 C.F.R. 98.33, MANDATORY GREENHOUSE GAS REPORTING Subpart C: General Stationary Fuel Combustion Sources
- 4 United States Environmental Protection Agency (US EPA) 2019f, Natural Gas Star 'Replace Compressor Cylinder Unloaders' (2019) Available at www.epa.gov/natural-gas-star-program/replace-compressor-cylinder-unloaders
- 5 United States Environmental Protection Agency (US EPA) 2019e, Natural Gas Star 'Install Automated Air/Fuel Ratio Controls' (2019) Available at www.epa.gov/natural-gas-star-program/install-automated-airfuel-ratio-controls
- 6 United States Environmental Protection Agency (US EPA) 2019a, Natural Gas Star 'Install Electric Compressors' (2019) Available at www.epa.gov/natural-gas-star-program/install-electric-compressors
- 7 United States Environmental Protection Agency (US EPA) 201b, Natural Gas Star 'Replace Gas Starters with Air or Nitrogen' (2019) Available at www.epa.gov/natural-gas-star-program/replace-gas-starters-air-or-nitrogen
- 8 United States Environmental Protection Agency (US EPA) 2019c, Natural Gas Star 'Install Electric Motor Starters' (2019) Available at www.epa.gov/sites/production/files/2016-06/documents/installelectricstarters.pdf
- 9 Canadian Association of Petroleum Producers (CAPP), Explorers and Producers Association of Canada, the Gas Processing Association Canada, Energy Resources Conservation Board and Natural Resources Canada Fuel Gas Management Practices (FGBMP) (January 2008)



METHANE GUIDING PRINCIPLES

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This series of 10 Best Practice Guides have been designed to improve performance in methane emissions management across the natural gas supply chain. Each Guide provides a summary of current known mitigations, costs and available technologies as of the date of publication. The Guides are available, upon request, in English, French, Arabic, Mandarin, Russian and Spanish.